MINE ADVICE Pty Ltd
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27th August 2014

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Report No. CHAINVALLEY04/01

Dear Mick,

SUBJECT: Independent Peer Review of Subsidence and Impact Assessment Undertaken by Ditton Geotechnical Services Pty Ltd: Chain Valley to Mannering Colliery Connection Roadways

This letter report provides details of the various outcomes from an independent review by the signatory of a detailed subsidence and impact assessment (Ditton Geotechnical Services [DGS] 2014) relating to the proposed drivage of up to four connection roadways between Chain Valley and Mannering Collieries (see Figure 1). These roadways are required to allow coal resources at Mannering (owned by Centennial Coal) to be exploited by Chain Valley (owned by LakeCoal) and also to provide a coal conveying route out through Mannering to supplement the existing coal clearance system at Chain Valley.

There is little doubt that the economic case for the proposed connection roadways is substantial. However this has been given no weight by this review which has focused solely on the prediction of any associated subsidence impacts upon overlying surface features, the report being compiled under the general principles of the expert witness code of conduct for Local, District and Supreme Court matters as set out in Schedule 7 to the *Uniform Civil Procedure Rules 2005* (NSW), this being to ensure the impartiality of the review outcomes.

It is understood that the proposed connection headings are sufficiently close to a number of surface features to warrant a subsidence impact assessment, including the Mannering Creek Ash Dam, a section of Lake Macquarie foreshore, a sewer line, a buried optic-fibre cable, a number of concrete treatment ponds and various transmission towers/sub-station infrastructure that is operated by TransGrid.

1. Completeness of the Subsidence Impact Assessment Study and Report (DGS 2014)

Overall, the DGS subsidence impact assessment is judged to be a comprehensive study whereby the various mechanisms that could conceivably result in significant levels of surface subsidence occurring have been identified and evaluated in detail.

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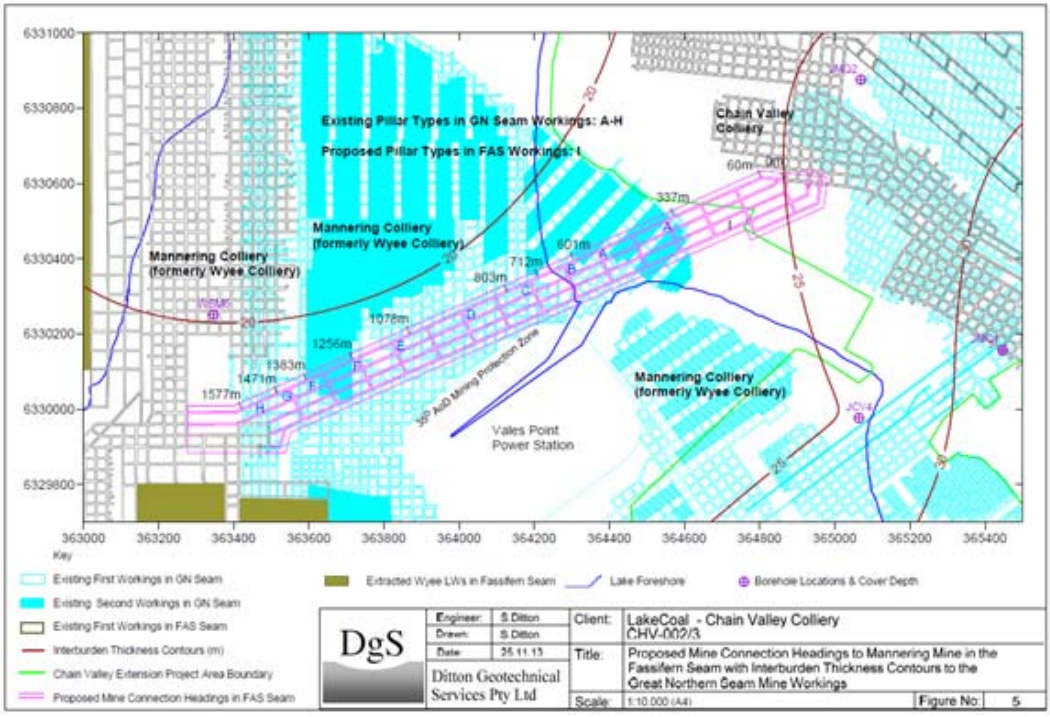

FIGURE 1. General Arrangement of Proposed Connection Headings and Overlying Mine Workings (Reproduced Figure 5 from DGS 2014)

In specific terms, the DGS impact assessment addresses the following material considerations:

(i) The likely stability of the proposed coal pillars between the connection headings in the Fassifern Seam

(ii) The likely stability of the pre-existing standing coal pillars within both first and second workings areas in the overlying Great Northern Seam

(iii) The potential for vertical ground movements, including up to surface, as a direct result of the presence of soft strata unit(s) in the immediate floor of the connection headings in the Fassifern Seam

(iv) The presence or absence of thick and massive strata units within the overburden that have the potential ability to (a) span across mining panels thus limiting the upward progression of vertical strata movements due to mining and/or (b) truncate the upwards progression of any localised roof falls that may occur within the connection headings either during or after mining is complete.

(v) The potential for direct stress interaction between the existing Great Northern Seam workings and proposed connection headings in the Fassifern Seam that will be located in the order of 22 m below the Great Northern Seam, the threat being the potential inadvertent de-stabilisation of what are otherwise currently stable workings in the GN Seam.

Figure 2 contains a general cross-section (to an approximate scale) from the Fassifern Seam up to surface so that both the vertical proximity of mine workings in different coal seams and the relative scale in terms of the coal removal to be required as part of the proposed connection headings can be visualised.

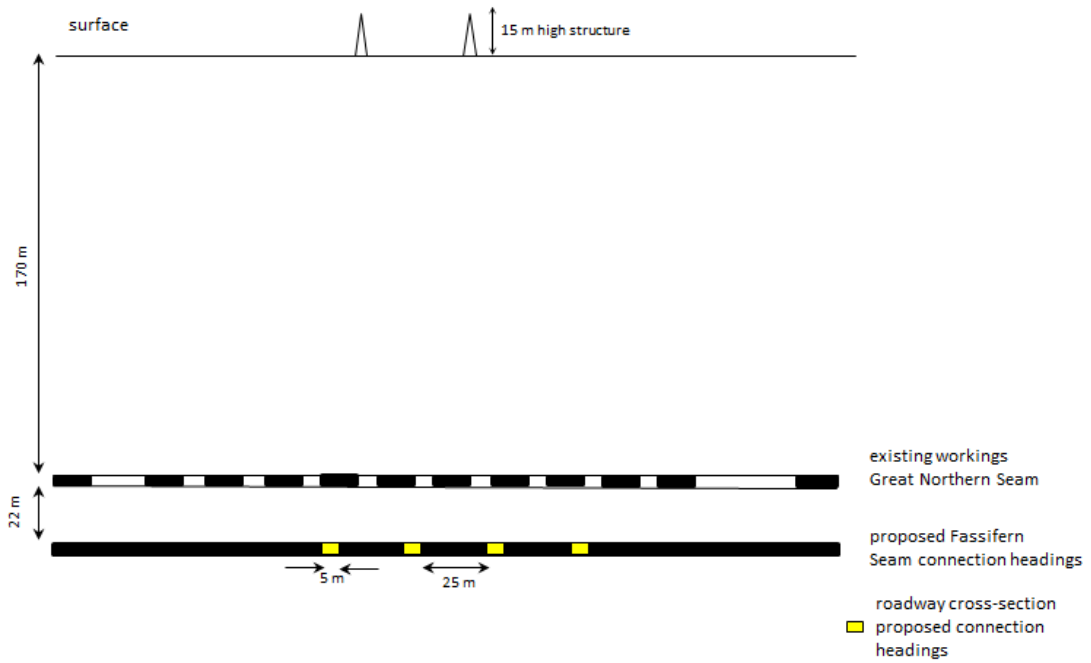

FIGURE 2. Approximate Scale Cross-Section from Surface to Fassifern Seam in Area of Proposed Connection Headings

In terms of the evaluation process used by DGS, the following comments are made:

(i) The geological and geotechnical characterisation is assessed to be comprehensive in its content in that it addresses the necessary parameters associated with the various behavioural mechanisms that could result in significant surface subsidence. The three exploration boreholes upon which the characterisation is based "triangulate" around the proposed connection headings, however none directly intersect the actual area of the headings. This in itself does not negate the characterisation presented as uncertainty in geological and geotechnical conditions between surface boreholes is always present in pre-mining geotechnical design. In this case it simply means that prudence demands that confirmatory geotechnical information be collected during the drivage of the connection headings, particularly as it relates to the thickness and nature of soft material in the immediate floor of the Fassifern Seam headings.

(ii) Coal pillar stability has been evaluated using the UNSW Pillar Design Procedure (UNSW PDP) which is fully appropriate and best practice for the type of mine workings involved.

(iii) A significant effort has been made to provide rational and logical explanation for previous unexpected surface subsidence "events" in the general vicinity, these relating to the time-dependent behaviour of soft floor measures directly beneath Great Northern Seam workings. Offering a credible explanation for measured time-dependent subsidence behaviour (see Figure 3 as an example) that when it was occurring resulted in significant cause for concern as to long-term outcomes, is a significant contribution to the DGS impact assessment, particularly as it has been linked to a well-established

aspect of claystone stability under vertical loading, namely the exceedance of pre-consolidation pressures resulting in primary and secondary consolidation over time.

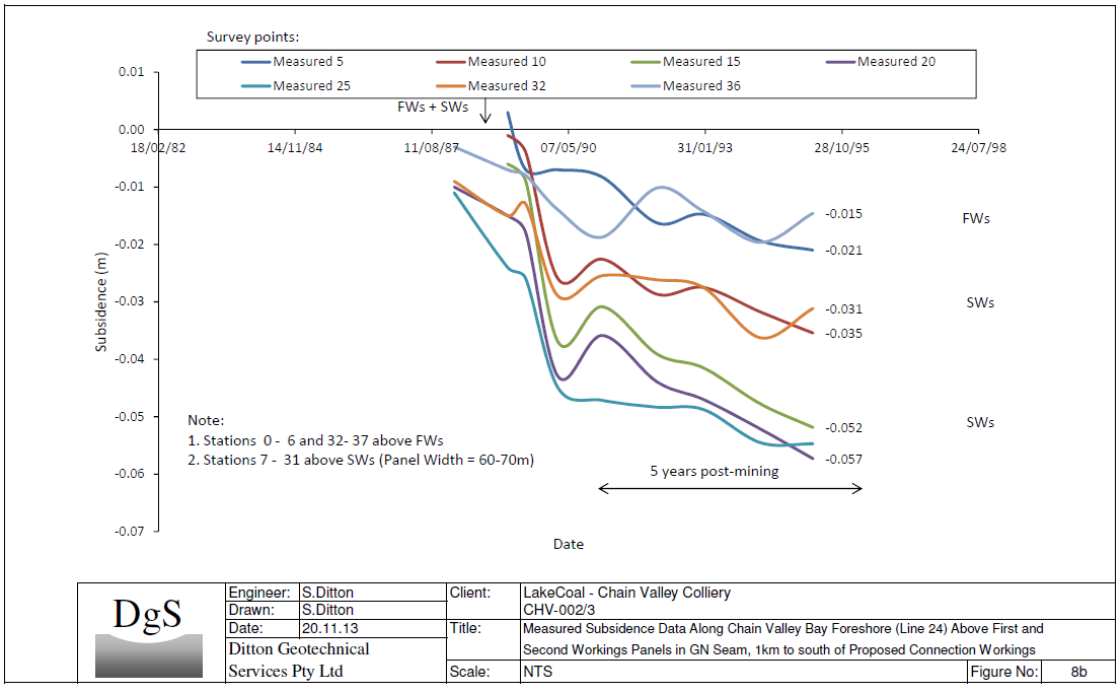

FIGURE 3. Measured Time Dependent Subsidence Behaviour above Comparable GN Seam Workings (Reproduced Figure 8b from DGS 2014)

(iv) The influence of multi-seam stress interactions between the proposed connection headings in the Fassifern Seam and overlying GN Seam workings has been evaluated using both a recognised numerical model that is commonly used in such situations (i.e. LaModel) in conjunction with an analytical treatment using the well-known Boussinesq method of evaluating stress changes below (and above) loaded footings (including a coal pillar). A combination of analytical and numerical evaluation is judged to represent a relatively robust approach to evaluating this key issue.

(v) In terms of the stabilising or subsidence-limiting effect of thick and massive strata units in the overburden, even though their presence is detailed in the geological and geotechnical characterisation, they are only used as a mitigating factor as the predictions of subsidence levels following heading development in the Fassifern Seam effectively ignore their presence. This also introduces further robustness into the study outcomes as the impact assessment is conducted on what is then a conservative basis with the likely outcomes in practice then being less than the predicted levels.

Overall, the author fully agrees with the process that has been adopted by DGS in their analyses and assesses it to be fit for purpose in this instance.

2. Comments on Subsidence Predictions and Associated Impact Assessment

The two most fundamental issues relating to the prediction of surface subsidence effects due to the drivage of the proposed connection headings are:

(a) the stability of the resultant mine workings in the Fassifern Seam, and then as a direct consequence,

(b) any impact upon the future stability of the already existing GN Seam workings.

These two key issues will now be individually commented upon.

2.1 Stability of Proposed Mine Workings in the Fassifern Seam

On the understanding that no secondary extraction will ever occur in the vicinity of the proposed connection headings, their future stability can be evaluated simply based on first workings.

With coal pillar Factor of Safety (FoS) values in excess of 3 under Full Tributary Area Loading (which is a conservative assumption for a 4 heading development panel at the depths involved) plus an allowance for multi-seam interaction, it is concluded that structural instability of the proposed coal pillars in the Fassifern Seam headings is not a credible possibility.

In terms of vertical strata movements due to any associated compression of claystone units in the floor of the Fassifern Seam, the analysis undertaken has demonstrated that the pre-consolidation pressures of such material will not be exceeded. Therefore the type of post-mining subsidence movements that have previously been associated with old GN Seam workings (see Figure 3 again) should not occur. This is not a surprising outcome given the limited proposed coal removal in the Fassifern Seam (see Figure 2) and the associated relatively minor changes in vertical stress acting through the coal and into the floor measures.

The author concurs with the stability assessment for the proposed connection headings in the Fassifern Seam, namely that there is no obvious source of substantial strata failure that could result in significant surface subsidence effects being generated.

2.2 Impact on the Overlying GN Seam Workings

There is little doubt that should the formation of the connection headings in the Fassifern Seam significantly de-stabilise the overlying GN Seam workings, substantial additional subsidence effects would occur at surface.

The overall finding in Section 2.1 is relevant as the Fassifern Seam is close enough to the GN Seam (vertical separation of just greater than 20 m) to be considered as part of the “foundations” for the GN Seam workings. Obviously if the foundation of any structure such as a bridge or building undergoes a substantial change in state, it may jeopardise the stability of the structures it is designed to support and the same is true of the foundations for mine workings.

If the formation of the connection headings and associated coal pillars caused (as an example) the floor of the GN Seam workings to decouple from the coal pillars in the GN Seam, it would have the obvious potential to de-stabilise the GN Seam workings in their entirety as a direct result. However for this to occur, the floor of the GN Seam would need to lower sufficiently to overcome or unload the vertical stresses acting in the coal

pillars and the floor itself. This would require substantially more lowering of the GN Seam floor than that associated with long-term stable workings in the Fassifern Seam.

The analysis presented in DGS 2014 is judged to be sufficient to confirm that the formation of the proposed connection headings and associated coal pillars poses no credible threat to the future on-going stability of the overlying GN Seam workings.

3. Comments on Predicted Additional Subsidence due to Drivage of the Connection Headings and Associated Impacts

Having reliably established that the formation of the proposed connection headings in the Fassifern Seam poses no credible threat to the on-going stability of the pre-existing GN Seam workings, the prediction of associated surface movements can be undertaken using cumulative compression in the various strata units that will undergo changes in vertical stress as a result of heading formation.

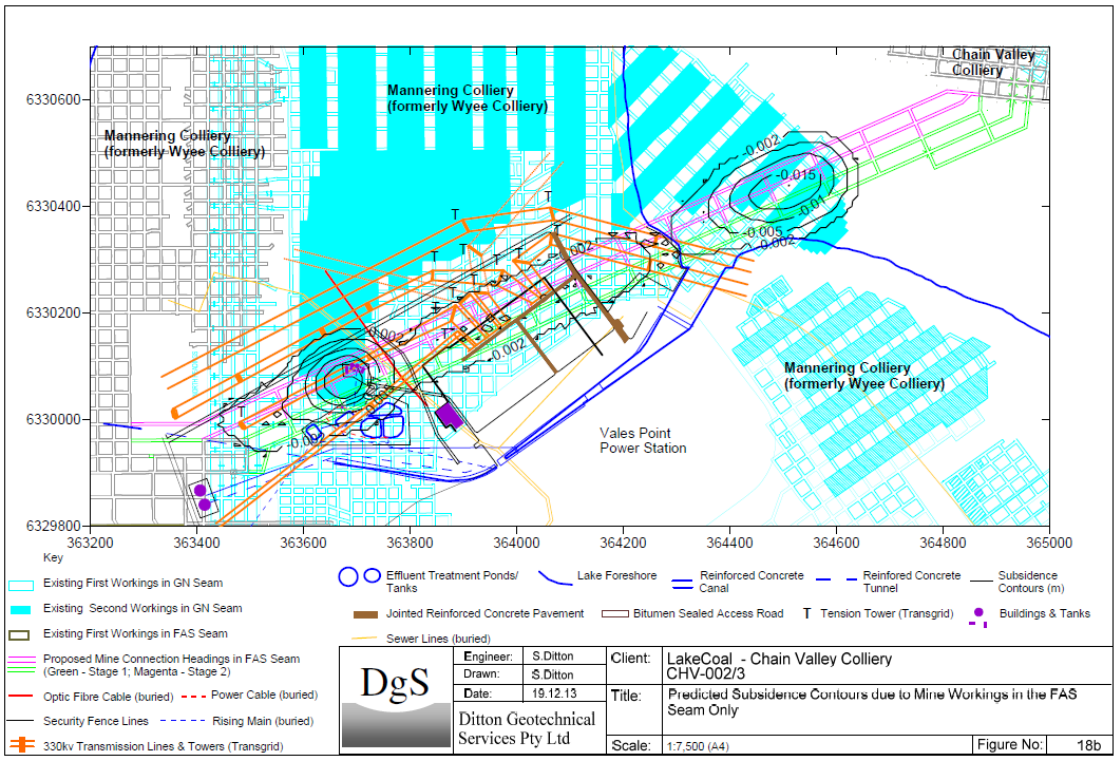

FIGURE 4. Predicted Subsidence Isopachs Due to the Formation of the Connection Headings in the Fassifern Seam and Surface Features (Reproduced Figure 18b from DGS 2014)

The analyses undertaken and presented in DGS 2104 are judged to be suitably detailed to return credible values for surface lowering (S_{max}) and any associated parameters such as curvature, tilt and strain that are directly linked to the magnitude of S_{max} (i.e. they increase in line with increasing S_{max}) and are primary damage drivers for surface features. The various sources of conservatism used in these calculations is also noted, particularly the assumption of Full Tributary Area Loading for the proposed Fassifern Seam pillars and the

non-inclusion of thick massive strata units that may tend to mitigate against the development of the full predicted additional subsidence levels.

Figure 4 shows isopachs of the increase in surface subsidence as a direct result of forming the proposed connection headings along with the various surface features that are of relevance. This figure along with those detailing tilts, curvatures and strain provide a credible basis for assessing the likely impact on the various defined surface features due to the formation of the Fassifern Seam connection headings.

The areas of pre-existing second workings in the Great Northern Seam are logically where the highest level of additional surface subsidence has been predicted due to the formation of the connection headings. Up to 25 mm of additional vertical lowering is predicted in these areas, albeit that the lake foreshore is limited to in the order of 2 mm of additional lowering due to the Great Northern Seam workings having been restricted to first workings directly under the foreshore.

The TransGrid infrastructure of the Vales Point sub-station and nearby transmission towers (some of which are known to be tension towers) is situated above first workings in the Great Northern Seam such that the predicted increase in vertical subsidence as a result of forming up the proposed connection headings in the Fassifern Seam is 6 mm and less, again noting the conservative assumptions used by DGS when calculating these values. The associated maximum values of curvature, tilt and strain are < 0.03 km^{-1}, < 0.2 mm/m and < 0.3 mm/m respectively. Figure 4 also indicates that the majority of the TransGrid tension towers are located outside the 2 mm additional surface lowering isopachs so will be influenced by < 2 mm of vertical lowering due to the proposed mining.

Overall, it is judged that the vertical subsidence predictions provided by DGS 2014 are at the absolute low end of what can be considered as "meaningful predictions" in that any lower values would almost certainly lead to a conclusion of "zero" subsidence. It is considered that the various predictions as they relate to TransGrid infrastructure can be classified as "imperceptible" levels of increased surface subsidence as it is likely that they will result in no obvious visible changes to surface conditions and may not even be detectable using survey methods (dependent upon local near-surface strata conditions).

In their submission dated 14th August 2014 TransGrid note that "*the existing transmission towers and the Vales Point sub-station have not been designed or constructed to allow for any tolerance from subsidence impacts*". Whilst this is taken as factual, it is inevitably the case that those structures have been designed to include levels of design conservatism consistent with their critical importance to the electricity supply network that they support. Therefore it must surely also be the case that they are able to accommodate some level of disturbance due to mining subsidence without inevitably resulting in "*long-term damage to TransGrid's Vales Point sub-station and approximately 21 transmission towers*".

As a final comment, in any cases whereby underground coal mining was to include substantial secondary extraction in close proximity to such electricity network infrastructure, the author would inevitably conclude that the infrastructure not having been designed to accommodate mining subsidence impacts was a fatal flaw and that consequently such mining would indeed represent a major threat to its continued stability and serviceability. However in this particular instance whereby the type of mining being contemplated is limited to highly stable first workings only, the author is compelled to conclude that the infrastructure not being designed

for mining subsidence impacts does not in any way automatically result in a credible threat to its future stability and serviceability.

Please do not hesitate to contact the undersigned should you have any further questions.

Regards,

Dr. Russell Frith
Principal Geotechnical Engineer

REFERENCES

Ditton Geotechnical Services (2014). Subsidence Assessment for the Proposed Underground Headings Between Chain Valley Colliery and Mannering Colliery. Commercial consulting report # CHV-002/3 dated 27th January 2014.